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# SCIENCE

FRIDAY, JULY 9, 1920

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## THE SCIENTIFIC BASIS OF THE ILLINOIS SYSTEM OF PERMANENT SOIL FERTILITY<sup>1</sup>

It is practically impossible to cover, in an adequate way, the scientific principles underlying the Illinois system of permanent soil fertility in the brief space of time allotted me on the program. Nevertheless, I shall point out the fundamental principles underlying the system without attempting to illustrate the points made by definite data as I should like to do.

Eighty years ago Liebig, the father of agricultural chemistry, made the following statement:

Agriculture is, of all industrial pursuits, the richest in facts, and the poorest in their comprehension. Facts are like grains of sand which are moved by the wind, but principles are these same grains cemented into rocks.

The great contribution made to American agriculture by the late Dr. Hopkins was the gathering together, classifying, interpreting and unifying, by his own investigations the known facts of agriculture, into a definite whole as practised and taught by him in the Illinois system of permanent soil fertility.

Many of the facts upon which the Illinois system rests have been known for many years and even centuries and have been developed by other men in other institutions and in other times. It remained, however, for Dr. Hopkins to bring together and unify these isolated facts into a definite workable system and by his own investigation to demonstrate clearly that the system could be understood and used by the average farmer on his own farm with very profitable results. In his interpretation of the facts upon which the system is based, all men have not agreed and some even still do not agree with him but the system rests on the

<sup>1</sup> An address given at the Hopkins Memorial, January 22, 1920

sure foundation of facts supported by an abundance of experimental data now available from the fields and laboratories of the University of Illinois operated under his direction.

The Illinois system recognizes clearly that there are six positive factors of crop production. These factors of crop production may be briefly indicated by single terms as the seed, temperature, moisture, light, a home for the plant, and food for its use. These factors are all of equal importance in the production of crops. Not all of the factors, however, are susceptible of equal control. It is impossible, for example, to change the temperature conditions of winter so as to make that season suitable for crop production, and the practical means available for modifying the temperature conditions of the soil during the growing period of the crop are very limited. Of all the factors of crop production, the food factor is completely within the control of the farmer. It is fully possible for him to completely change, in an economic way, the amount of food available for the plant within the soil. It is frequently true, also, that the food supply is the limiting factor of crop production, especially under humid conditions such as prevail in Illinois.

The Illinois system of permanent soil fertility, therefore, deals in a large measure with this factor of crop production. There are 10 essential elements of plant food and these are carbon, oxygen, hydrogen, iron, sulfur, calcium, magnesium, potassium, nitrogen and phosphorus. All of these ten elements of plant food are of equal importance in crop production, for, in the absence of any single one, the plant can not function normally and produce a good yield of its kind. Not all of the plant foods, however, are within the control of the farmer, while some of them are obtained from natural sources in sufficient quantities so that they never limit crop yields.

Carbon and oxygen are obtained by the plant from the small amount of carbon dioxide of the atmosphere, and this supply is constantly being replenished from natural sources. Hydrogen is obtained by the plant from the soil moisture which in turn is being constantly re-

plenished by the rainfall under humid conditions. The plant consists largely of these elements of plant food, their compounds forming approximately 95 per cent. of all plant parts. These three elements of plant food are constantly being replenished in the soil or air from natural sources, and the farmer, therefore, need not concern himself further with them.

Iron is used by the plant in such extremely minute quantities, and the supply in the soil is so large, that it need never be added to the soil as a plant food. While the plant food requirements for sulfur are comparable in many respects with those for phosphorus, sulfur is constantly being added to the soil from natural sources in quantities more than sufficient to meet the needs of the plant for food. For these reasons, these two elements need no special consideration in a permanent system of soil fertility.

There remain, therefore, five elements of plant food which must receive careful consideration by the farmer in any system of permanent soil fertility which may be proposed. These elements are calcium, magnesium, potassium, phosphorus and nitrogen. A system which assumes to be permanent must provide for the return to the soil of those elements of plant food removed by the crop, unless they are present in the soil in unusual quantities sufficient to provide for the maximum production of crops for indefinite periods of time. The Illinois system considers and makes such provision for these five elements of plant food.

The inorganic plant foods, calcium, magnesium, potassium and phosphorus, are removed by the plants in comparatively large quantities. An ordinary rotation of wheat, corn, oats and clover would remove, for the maximum production of crops, 77 pounds of phosphorus, 320 pounds of potassium, 68 pounds of magnesium and 168 pounds of calcium, and these substances are obtained by the plant from the soil and there is no other possible source unless materials containing them are added to the soil. It is, therefore, of fundamental importance to know the amounts of these materials which occur in the soil and

to determine their relation to the requirements of the plant.

Various chemical methods have been proposed from time to time for analyzing the soil. Most of these have been based upon the fantastic claim that they determine the "available" plant food in the soil. Dr. Hopkins early realized the futility of such a claim, and concerned himself only with the determination of the total amounts of plant food within the soil. He used chemical analysis as a means of taking an invoice of these substances within the soil, just as the merchant takes an invoice of the goods upon his shelves. Whether or not the farmer makes the proper use of this material, depends largely upon him and the kind of farming he carries on, just as it depends upon the business ability of the merchant whether or not his business is successful, but in both cases an accurate invoice of stock with which he must work is as absolute a necessity for the farmer as for the business man.

The chemical analysis of the soils of Illinois, carried on with this idea in mind, soon showed a marked variation in the amounts of the various essential plant foods present in the soil. The brown silt loam of Campaign county, for example, contains over 9,000 pounds of magnesium, 10,000 pounds of calcium, 35,000 pounds of potassium, and only 1,000 pounds of phosphorus in the plowed surface soil. As measured by this accurate soil invoice, phosphorus is the most limited element in the soil, and, as measured by the crop requirements also, it is found that phosphorus is the most limited of plant foods in this typical corn belt soil. There is sufficient calcium present, for example, for the production of a 100 bushel crop of corn for 90 centuries. There is sufficient magnesium for 13 centuries, sufficient potassium for 18 centuries, while there is sufficient phosphorus for only 62 years, even if it could be utilized by the plant, and provided a maximum crop of 100 bushels of corn were produced and all material except the grain is returned to the soil. These illustrations are typical, and are very significant in emphasizing the importance of phosphorus to crop pro-

duction, and indicate clearly its marked deficiency in the soil.

The fifth element, nitrogen, is very important. It is used by the plant in large quantities, and when purchased upon the markets of the world it is the highest priced of all materials. A hundred pounds of nitrogen are required for the production of 100 bushels of corn, and nitrogen at present is selling for \$.30 a pound. The maintenance of the nitrogen supply of the soils is, in the language of Dr. Hopkins, "the most important practical problem confronting the American farmer." It is quite evident that the farmer can not afford to purchase commercial nitrogen for the production of his common farm crops. A tax on corn of \$.30 per bushel for this purpose is absolutely prohibitive. The farmer must, therefore, depend upon legume nitrogen which is obtained by legumes such as clover, alfalfa, soybeans, etc., by the aid of symbiotic bacteria from the inexhaustible supply in the air, provided the soil conditions are favorable to their growth and development. It is, therefore, necessary that a legume occur in the rotation and that the legume hay or chaff produced must be carefully conserved and returned to the soil, either as farm manure or green manure crops. It is of importance, also, that the utmost use be made of legume cover crops grown in connection with the production of wheat, and other cereals, and in the development of this use of legume cover crops the research work of Dr. Hopkins is particularly outstanding. Sweet clover was a favorite crop with him for this purpose, and he was among the first to call attention to its great possibilities. Unfortunately, legumes, so essential for soil improvement, can not be successfully grown on many soils in Illinois, as they now exist, because of the acid soil conditions which frequently absolutely prevent their growth.

A limestone soil is a rich soil, is an age old truth. Soils which have become famous everywhere for their persistent fertility are limestone soils. This is true of the soils of the far western United States, the bluegrass regions of Kentucky, the valley of the Nile, the black soils of India and Russia. Limestone,

therefore, is of fundamental importance in soil fertility. Unfortunately, limestone is easily soluble in carbonated water, and of all soil constituents probably is most readily lost in the drainage water. Humid soils, as a rule, are, therefore, deficient in this essential constituent, and the first principle of soil fertility is that limestone must be added to those soils in which it is not already present. The limestone is added primarily for the purpose of creating conditions favorable to the growth of the necessary legume crops, although it also has a markedly favorable action in increasing the yields of the cereal crops in the rotation.

There are various forms and kinds of limestone materials available for use, but the work of Dr. Hopkins has clearly demonstrated that the most economic form to use is the finely ground natural limestone—the normal material occurring in the soil. The abundance of data obtained by him on the various experimental fields for the use of finely ground limestone, particularly in southern Illinois, furnish now the best information the world affords regarding the great benefit from the use of limestone for the production of common farm crops. The addition of limestone to the soil not only corrects the acid conditions but also provides the necessary calcium and magnesium as plant foods.

In most normal soils, such as the brown silt loam of the corn belt, potassium occurs in the soil in such large quantities that it will last for the maximum production of crops for indefinite periods of time and so, in the case of potassium, the problem of the farmer is not one of addition to such soils, but is one of liberation from the insoluble compounds contained in soil. A normal soil, well supplied with fresh decomposing organic matter as provided in the grain or livestock system of farming, will provide sufficient potassium to meet the requirements of crops for this element; and the experimental results, obtained from the various experimental fields for addition of potassium, have shown clearly that it not only does not pay for itself, when used on such soils, but gives little actual increased yield.

There are certain abnormal types of soil on

which potassium is absolutely essential. Such soils are peaty soils and soils deficient in organic matter. On peaty soils, potassium is the limiting element of plant food and is often the limiting factor of crop production. The addition of potassium, therefore, to such soils is an absolute necessity. On soils deficient in organic matter, such as many of those occurring in southern Illinois, potassium may be used with profitable results until the soil has been built up in its organic matter content.

On normal soils, phosphorus is frequently the limiting element of crop production. There are various forms of phosphorus available for use such as barnyard manure, steamed bone meal, basic slag, acid phosphate and raw rock phosphate. Of the various forms available, the abundant experimental data, obtained from the experimental fields maintained by the university, prove conclusively that the finely ground raw rock phosphate may be used with considerable profit and, for economic reasons, this form of phosphorus is regarded as the most desirable form to use although there may be special conditions under which some of the other forms may be used.

There are two well-defined types of farming occurring in Illinois. These are the grain system of farming and the livestock system of farming. Both of these are perfectly legitimate, proper, necessary and profitable systems of farming, and it is possible and feasible to provide means whereby the fertility of the soil may be maintained on a permanent and profitable basis in either case. Both types of farming are absolutely necessary and essential to the development of the highest stage of civilization, for as long as man demands bread, butter, meat and milk, and until we are willing that our standard of living shall be lowered, both of these types of farming must exist. It is essential, therefore, that provision be made whereby the fertility of the soil may be maintained in order that grain and livestock farming may become permanent institutions in the land. The Illinois system of permanent soil fertility recognizes this fact, and makes provisions for the maintenance of

fertility on both the livestock and the grain farm. In either type of farming, limestone and phosphate must be used so as to permit the growth of legumes so essential in soil improvement and also in the feeding of livestock.

While Dr. Hopkins took particular pains to point out and emphasize the possibility of maintaining the fertility of the soil on the grain farm on a permanent and profitable basis, he also made important contributions to our knowledge regarding methods of maintaining the fertility of the livestock farm. The teachings of Dr. Hopkins in this respect are of tremendous importance since they provide for the extension of livestock farming to large areas where heretofore the proper feeds could not be produced. On all of the experimental fields just one half of the work is devoted to the maintenance of soil fertility in livestock farming. The livestock farmers of Illinois should have a deep sense of gratitude to Dr. Hopkins for his work in their behalf.

If a system is to be permanent, the materials removed from the soil must be returned, at least in the proportion in which they are removed by natural processes, including the amount removed by the crop and the amount lost in the drainage water. This would seem to be such a simple axiomatic truth that it need not be dwelt on; however, it is a point which must be constantly emphasized again and again. The use, therefore, of two or three hundred pounds of an ordinary commercial fertilizer of a 2-10-2 grade, which adds only five or six pounds of nitrogen, must act purely as a soil stimulant. For, if increased crops are obtained by its use, they can be obtained only at the expense of the nitrogen already in the soil, since the requirement for a 100 bushel crop of corn is 100 pounds of nitrogen. The Illinois system of permanent soil fertility, therefore, condemns in unmeasured terms the use of such soil stimulants, among which must be classified ordinary mixed commercial fertilizers and gypsum.

In the briefest way possible, the very essential points underlying the Illinois system of permanent soil fertility have thus been merely touched upon. But it is the desire to empha-

size at this point that the Illinois system of permanent soil fertility rests upon a sane and safe scientific basis, and, because it makes abundant use of cheap, natural, raw, products, as legume nitrogen and finely ground materials such as limestone and rock phosphate, it is both a permanent and profitable system of soil fertility. This is the heritage to Illinois farmers left by him in whose memory we have met here to-day.

ROBERT STEWART

UNIVERSITY OF ILLINOIS

### RADICALISM AND RESEARCH IN AMERICA

INVESTIGATORS who are concerned as to the possibility of adequate facilities for research being maintained by popular governments, or who doubt whether a republic working through democratic institutions like our National Research Council can equal the scientific attainments of autocratic Germany, will derive much encouragement from a review of American history. Prominent among the agencies which, in addition to privately endowed institutions, have supported the prosecution and publication of scientific research in this country are Academies of Science, State Universities, Land Grant Colleges and Agricultural Experiment Stations, Federal Department of Agriculture, Coast and Geodetic Survey and the State and National Geological Surveys. In many cases the inception or period of most marked development of these institutions has been closely linked with striking political developments. Without presenting any unpublished data the present paper aims to assemble some of the facts which seem significant in this connection.

Undoubtedly the most radical document ever adopted by an American national assembly was the Declaration of Independence. The active members of the committee appointed to draft this instrument were Franklin, Adams, and Jefferson, each of whom made a distinct contribution to the advancement of scientific foundations in America.

Franklin's fame as a scientist, as a diplomat, and as leader of the radical faction in our

constitutional convention make comment on these points unnecessary. Of special interest here is his activity in founding our first academy of science.<sup>1</sup> As early as 1743 Benjamin Franklin issued his circular entitled "A proposal for promoting useful knowledge among the British plantations in America," in which he urged the establishment of a society to be called "The American Philosophical Society." From this Society and another organized in 1766, of which Franklin was first president, grew in 1769 The American Philosophical Society of to-day. Of this society Franklin was president from its organization until his death and Dr. Benjamin Rush, one of the signers of the Declaration of Independence, was one of the secretaries. The American Philosophical Society began in 1771 the publication of the *American Philosophical Transactions* and soon assumed national importance and assisted in making Philadelphia for many years "the metropolis of American Science."<sup>2</sup>

To John Adams, who in 1776 seconded the famous resolution of Richard Henry Lee that "these colonies are, and of right ought to be free and independent states" and bore the foremost place in the debate on the adoption of the Declaration of Independence, our second Academy of Science owes its origin. The circumstances which led to Adams' deep and lasting interest in scientific foundations, and his part in founding the American Academy of Arts and Sciences which was incorporated by the legislature of Massachusetts in 1780 and published its first memoirs in 1785, are detailed by Goode.<sup>3</sup> One of the original members of the American Academy of Arts and Sciences was Levi Lincoln, Attorney-General of the United States under Jefferson.

When Washington became president these two societies were the only scientific organiza-

tions in this country and it is worthy of note that the president, vice-president and the secretary of state in that first administration were all fellows of the American Philosophical Society. The efforts of Washington himself and later of Madison to establish a national university might well be mentioned here but for the fact that the national university which was urged in presidential messages over a century ago is not yet an accomplished fact.

The activities of the author of the Declaration of Independence in behalf of science and education are well known. In the opinion of Goode<sup>4</sup>

no two men have done so much for science in America as Jefferson and Agassiz—not so much by their direct contributions to knowledge as by the immense weight which they gave to scientific interests by their advocacy.

In 1782 appeared Jefferson's "Notes on the state of Virginia,"<sup>5</sup> the first comprehensive treatise on the natural history and resources of one of the states, and the precursor of the numerous state surveys since issued. When in 1797 Jefferson came to Philadelphia to be inaugurated vice-president<sup>6</sup> he brought with him a collection of the fossilized bones of some large quadruped and the manuscript of a memoir upon them, which he read before the American Philosophical Society. "The spectacle," remarks Luther,<sup>7</sup> "of an American statesman coming to take part as a central

<sup>4</sup> Goode, George Brown, "The Beginnings of Natural History in America," Rpt. U. S. Nat. Mus., 1896-97, p. 394, 1901.

<sup>5</sup> The first edition, 1782, was published in Paris and but few copies were printed. The preface to the second edition, London, 1787, states with reference to the Paris edition "the subjects are all treated imperfectly; some scarcely touched on . . . They are now [1787] offered to the public in their original form and language."

<sup>6</sup> Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, p. 280, 1901.

<sup>7</sup> Luther, F. N., "Jefferson as a Naturalist," *Mag. Amer. Hist.*, Vol. 13, No. 4, p. 386-387, April, 1885.

<sup>1</sup> Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, p. 266, 1901.

<sup>2</sup> Goode, George Brown, *op. cit.*, p. 268.

<sup>3</sup> Goode, George Brown, *op. cit.*, p. 268-269.

figure in the greatest political ceremony of our country and bringing with him an original contribution to the scientific knowledge of the world, is certainly one we shall not soon see repeated."

Jefferson's presidency Goode<sup>8</sup> calls the "most memorable in the history of American science." Not only was the president actively engaged in paleontological research, using one of the unfinished rooms of the White House<sup>9</sup> for the storage and display of some 300 specimens of fossil bones from the famous Big Bear Lick,<sup>10</sup> but his administration was marked by the inception of the system of scientific surveys of the public domain and the organization of the Coast Survey. Jefferson's part in originating and supporting the Lewis and Clarke expedition has been detailed by True.<sup>11</sup> And who ever originated the idea of a Coast Survey it is certain that the early organization of the survey itself was due to Jefferson.<sup>12</sup>

Nor was Jefferson's interest in scientific foundations limited to those which he origi-

<sup>8</sup> Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, p. 280, 1901.

<sup>9</sup> Merrill, George P., "Contributions to the History of American Geology," Rpt. U. S. Nat. Mus., 1903-04, p. 213, 1906.

<sup>10</sup> Such scientific tendencies were the object of much criticism in the more conservative portions of the country. The following lines from the "Embargo" written by William Cullen Bryant (when a boy of 13) probably represents public opinion in his locality.

Go, wretch, resign the presidential chair  
Disclose thy secret measures, foul or fair,  
Go, search with curious eyes for horned frogs,  
'Mid the wild wastes of Louisianan bogs,  
Or where the Ohio rolls his turbid stream  
Dig for huge bones, thy glory and thy theme.

<sup>11</sup> True, Rodney H., "Thomas Jefferson in Relation to Botany," *Sci. Mo.*, Vol. 3, No. 4, pp. 354-357, October, 1916.

<sup>12</sup> Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, p. 293, 1901.

nated and could further in some large way. When, a little over a century ago, Benjamin Silliman launched *The American Journal of Science* he was much concerned as to whether a sufficient subscription list could be maintained. Among those to whom he wrote asking for subscriptions was Jefferson, then in his seventy-fifth year. How Jefferson's reply, here quoted from Dana's article<sup>13</sup> must have heartened the first editor of what is now our oldest scientific journal, can best be appreciated, perhaps, by those who are still struggling with the question of adequate support for American scientific publications.

If not his most notable contribution to science and education, the foundation of our first state university was apparently the one nearest Jefferson's heart. His part, when well over seventy, in the foundation of the University of Virginia as originator, as organizer, as architect and as first head of the institution has been too well told<sup>14</sup> to warrant repetition. His special interest in the teaching of science in this university has been

<sup>13</sup> Dana, Edward S., "The American Journal of Science from 1818 to 1918," *Amer. Jour. Sci.*, Sr. 4, Vol. 46, No. 271, p. 30, July, 1918.

MONTICELLO, April 11, '18

Sir: The unlucky displacement of your letter of Mar 3 has been the cause of delay in my answer. altho' I have very generally withdrawn from subscribing to or reading periodical publications from the love of rest which age produces, yet I willingly subscribe to the journal you propose from a confidence that the talent with which it will be edited will entitle it to attention among the things of select reading for which alone I have time now left. be so good as to send it by mail, and the receipt of the 1st number will be considered as announcing that the work is commenced and the subscription money for a year shall be forwarded. Accept the assurance of my greatest esteem and respect.

TH. JEFFERSON

PROFESSOR SILLIMAN.

<sup>14</sup> Adams, Herbert B., "Thomas Jefferson and the University of Virginia," p. 308, pl. —, Washington, D. C., 1888. (U. S. Bur. Educ. Circ. Inform. 1.) True, Rodney A., "Thomas Jefferson in Relation to Botany," *Sci. Mo.*, Vol. 3, No. 4, pp. 345-360, port., October, 1916.

emphasized by True,<sup>15</sup> and that in Jefferson's mind at least, political radicalism and interest in higher education were clearly joined may be judged from the epitaph he himself prepared.

Here was buried Thomas Jefferson, author of the Declaration of Independence, of the statute of Virginia for religious freedom and father of the University of Virginia.<sup>16</sup>

If this subject were pursued into the field of state and local history much relevant data could be presented. Merrill<sup>17</sup> traces "the beginning of the work which resulted in the establishment of the State survey" in New York to a course of lectures on natural history delivered by Amos Eaton before the State Legislature in Albany during April, 1818, on the invitation of Governor DeWitt Clinton. Clinton, while best known historically for his work in behalf of the Erie Canal, was active in securing the abolition of slavery in New York state and in perfecting a system of free public schools and was the author of a series of letters signed "A Countryman" in reply to the "Federalist."

Edward Hitchcock's Survey of Massachusetts (1830-1833), which Merrill refers to<sup>18</sup> as marking "an epoch in American geological work, since it brought to a successful conclusion the first survey of an entire state at public expense," was also a result of the interest of a radical governor, Levi Lincoln, (son of the Lincoln mentioned above) who recommended the survey and Professor Hitchcock's appointment. Governor Lincoln is known in the history of his state as the first governor to exercise the veto power, and as the leader of the minority in the Massachusetts State Legislature who protested against the Hartford convention of 1814.

Nor was the fostering of science and education wholly the concern of individual radicals at this period. For hardly had the Democratic majority in Maine effected the separation of the state from Federalist Massa-

chusetts (1820) than the State Legislature made an annual grant of \$1,000 to aid in maintaining an institution which was to give mechanics and farmers "such scientific education as would enable them to become skilled in their professions."<sup>19</sup> This institution was incorporated as the Gardiner Lyceum and opened January 1, 1823.

The greatest radical movement after the Revolution was that which resulted in the abolition of slavery. Of those whose names have already appeared in this sketch, Jefferson and Clinton were conspicuous advocates of abolition. The first prominent opponent in Congress of the extension of slavery was probably John Quincy Adams. One is not surprised to learn that this sturdy individualist who changed his political affiliations at will and maintained an influential position in Congress for many years, independent of party and who refused to be silenced by the "gag rule" of 1837 was deeply interested in science and its advancement. As outlined by Goode<sup>20</sup> he revived Washington's National University project, worked for a national astronomical observatory, was actively interested in the foundation of the Smithsonian Institution and considered his most important achievement to be the Report on Weights and Measures prepared for Congress in 1818. Of this he was justly proud for it was a very admirable piece of scientific work. He found the presidency of the American Academy of Arts and Sciences so congenial to his tastes and sympathies that he did not hesitate to say that he prized it more highly than the chief magistracy of the nation.

It was during his term as president that the consuls in various parts of the world were instructed to send to the Department of State rare seeds and plants for distribution, and about the same time a Botanical Garden was

<sup>19</sup> True, A. C., "Agricultural Education in the United States," U. S. Dept. Agr. Yearbook, 1899, p. 163, 1900.

<sup>20</sup> Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, pp. 302-311, 1901.

<sup>15</sup> True, Rodney H., *op. cit.*, p. 359.

<sup>16</sup> True, Rodney H., *op. cit.*, p. 360.

<sup>17</sup> Merrill, George P., *op. cit.*, p. 234.

<sup>18</sup> Merrill, George P., *op. cit.*, p. 307.

established in Washington. These measures proved, according to True<sup>21</sup> to be the "germs from which has grown the United States Department of Agriculture."

The movement against slavery resulted in the election in 1854 of a majority in the House of Representatives of men pledged to oppose the extension of slavery. Among the members of the Republican majority which gained control of the House in 1855 was Justin S. Morrill, who in December, 1857,<sup>22</sup> introduced a bill "donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and mechanic arts." This bill, though finally passed by Congress, was vetoed by the reactionary Buchanan. A similar bill, however, introduced by Mr. Morrill in December, 16, 1861, was passed by both Houses and approved by Abraham Lincoln July 2, 1862, the very day when McClellan's army began its retreat from the Peninsula after the battle of Malvern Hill. Although under the provisions of the act ten per cent. of the fund might be expended for "the purchase of lands for sites and experimental farms,"<sup>23</sup> the chief significance of the Morrill Act for research lies in its relation to the subsequent and closely connected development of experiment stations.<sup>24</sup> After the fund which had been established by the sale of the landscript donated to Connecticut under the Morrill Act had been given to the Sheffield Scientific School of Yale University in 1863, a professor of agriculture was appointed. Under Samuel W. Johnson, professor of theoretical and agricultural chemistry and William H. Brewer, professor of agriculture in the Sheffield Scientific School, experimental work for the benefit of agriculture was carried on. And True<sup>24</sup> does not hesitate to ascribe to these men and their pupils more than to any other single cause,

<sup>21</sup> True, A. C., "Education and Research in Agriculture in the United States," U. S. Dept. Agr. Yearbook, 1894, p. 99, 1895.

<sup>22</sup> True, A. C., 1900, *op. cit.*, p. 167.

<sup>23</sup> True, A. C., 1895, *op. cit.*, p. 96.

<sup>24</sup> True, A. C., 1895, *op. cit.*, pp. 105-106.

the recognition of the importance of the establishment of agricultural experiment stations.

Professor W. O. Atwater, the first director of the first regularly organized experiment station in this country, was among the students trained in this school. From such a beginning grew the experiment stations of the United States, first regularly organized under the Hatch Act, approved by President Cleveland, March 2, 1887.

Although the chief energies of Lincoln's administration were turned toward the prosecution of our Civil War, Congress passed a bill establishing a Department of Agriculture, an act which became law by approval of President Lincoln on the 15 of May, 1862.<sup>25</sup>

Even during the trying days of reconstruction members of the first Republican Congress did not neglect scientific investigation and "in the spring of 1867 Hayden [F. V.] acting under the direction of the General Land Office, and with an appropriation from Congress amounting to \$5,000, began his work as U. S. geologist in Nebraska, and in so doing laid the foundation for the U. S. Geological Survey"<sup>26</sup> which "for breadth of scope and financial resources, is without counterpart in the world's history of science."<sup>27</sup>

To attempt to maintain that science can be encouraged only under popular governments would be impossible, even if desirable. The history of science and education in the United States does indicate, however, that in America there has been no antagonism between popular government and government supporting research. Radicals in America have never raised the cry "The Republic has no need of

<sup>25</sup> In calling attention to the fact that the bills creating our Land Grant Colleges and Department of Agriculture, were signed by the author of the Emancipation Proclamation and Gettysburg address, one is tempted to mention that the granting of a charter by Congress to the United States Agricultural Society was opposed in the Senate in 1855 by Jefferson Davis. (True, A. C., *op. cit.*, 1895, p. 92.)

<sup>26</sup> Merrill, George P., "Contributions to the History of American Geology," Rpt. U. S. Nat. Mus., 1903-04, p. 592, 1906.

<sup>27</sup> Merrill, George P., *op. cit.*, p. 551.

savants."<sup>28</sup> On the contrary those periods in which political radicalism has been most marked have been those in which science received most liberal governmental aid and encouragement.

NEIL E. STEVENS

BUREAU OF PLANT INDUSTRY,  
WASHINGTON, D. C.

### SCIENTIFIC EVENTS

#### BIOMETRIC AND EUGENIC LABORATORIES AT UNIVERSITY COLLEGE, LONDON

THE *British Medical Journal* states that the new building given by Sir Herbert Bartlett, Bt., to the Department of Applied Statistics formed by the Drapers' Company and Galton Laboratories at University College, London, was opened on June 4 by the Minister of Health. The Drapers' Company Biometric Laboratory was instituted under the direction of Professor Karl Pearson in 1904; it is a research laboratory and training school in the modern mathematical theory of statistics. The Galton Laboratory for National Eugenics was instituted in 1905, and was, by Sir Francis Galton's wish, associated with the other. When Sir Francis Galton died in 1911 he bequeathed a large part of his estate to found the Galton professorship, and Professor Karl Pearson was appointed to the chair. At the same time the senate of the university appealed for funds for building and equipment, and Sir Herbert Bartlett came forward with an offer to provide the building on a site at the northwest front of the college. During the war the new building was used as a military hospital, and only now has the department been able to take full possession. On the ground floor of the building is a large museum for the illustration of heredity, statistical proc-

<sup>28</sup> When during the "Reign of Terror" Lavoisier was condemned to death, a petition was presented to the rulers that his life might be spared for a few weeks in order that he might complete some important experiments, but the reply was "The Republic has no need of savants." (Goode, George Brown, "The Origin of the National Scientific and Educational Institutions of the United States," Rpt. U. S. Nat. Mus., 1896-97, p. 324, 1901.)

esses, and social problems, a lecture theater, a room for the exhibition of Galton relics and apparatus, and an anthropometric laboratory. On the first floor there are laboratories, a library, and a common room, and on the second a photographic studio, a large room for biometric workers in craniometry, and rooms for archives and instruments. The apartments in all number over twenty, and it was announced that a site has been reserved for extension, which will include animal breeding accommodation.

The vice-chancellor of the university, Dr. Russell Wells, who presided over the opening ceremony, said that statistics, properly understood, was one of the most difficult and advanced mathematical studies, but it was a dangerous weapon in the hands of the partially educated. Medicine in particular had suffered greatly from its misuse. The method introduced by Professor Karl Pearson would make it possible to arrive at the proof of many complicated medical problems. In sketching the history of the department, he reminded the audience of Florence Nightingale's well-known interest in statistics, and of her desire to found a professorship of applied statistics at University College, for which, however, her means were not sufficient. It was not until the generous provision of the Drapers' Company was made that a start became possible.

Dr. Addison gave an appreciation of the value of statistics which he had discovered when minister of munitions. There were few branches of public service with greater scope for the trained statistician than that of communal health, but here and in social science many statistics had been of a thoroughly incomplete and unsatisfactory nature. He commended to the support of the public the further appeal which University College was making to maintain and complete the equipment of the new building.

The provost, Sir Gregory Foster, expressed the thanks of those present to Dr. Addison. The thanks of the university to Sir Herbert Bartlett for his gift were expressed by the vice-chairman of the college committee, Dr. J. Bourne Benson. Professor Karl Pearson said

that one English monarch for whom he had a reverential regard was Henry VI. He saluted his statue whenever he crossed the lawn at King's College, Cambridge. In the fifteenth century it was possible to spend money on wars in France or on the founding of monasteries, but Henry chose to found King's College. And to encourage learning was still the surest way to secure that one's name was held in honor through grateful generations.

#### FISHERIES OF THE GULF STATES, 1918

DURING the past year the Bureau made a statistical canvass of the fisheries of the South Atlantic and Gulf States for the year 1918, and the returns for the latter section have recently been compiled and sent to press as Statistical Bulletin No. 470. The last previous canvass of these states by the Bureau was for the year 1902, and a later canvass was made by the Bureau of the Census for the year 1908. The statistics for the Gulf States cover the fisheries of the west coast of Florida and Alabama, Mississippi, Louisiana and Texas. In 1918 there were 14,888 persons employed in the fisheries of these states; the investment amounted to \$6,537,859; and the products aggregated 130,923,583 pounds, having a value of \$6,510,310. Of this total, the west coast of Florida produced 54,753,639 pounds, valued at \$3,420,363; Alabama, 5,609,219 pounds, valued at \$230,567; Mississippi, 20,592,089 pounds, valued at \$762,770; Louisiana, 24,953,876 pounds, valued at \$1,419,367; and Texas, 25,014,760 pounds, valued at \$677,243. Some of the more important species taken in these states were black drum, 2,011,288 pounds, valued at \$49,140; catfish, 851,265 pounds, valued at \$40,072; croaker, 714,692 pounds, valued at \$43,446; groupers, 5,935,825 pounds, valued at \$235,406; menhaden, taken mostly in Texas, 14,392,920 pounds, valued at \$109,939; mullet, including roe, 28,641,364 pounds, valued at \$1,318,379; redfish or red drum, 2,986,180 pounds, valued at \$175,109; red snapper, 9,429,802 pounds, valued at \$609,312; Spanish mackerel, 3,494,845 pounds, valued at \$215,197; squeteagues or "sea trouts," 4,960,738 pounds,

valued at \$414,593; shrimp, green and dried, 27,142,999 pounds, valued at \$1,098,427; and oysters, 23,754,465 pounds, or 3,393,495 bushels, valued at \$1,106,725. The output of sponges amounted to 452,188 pounds, valued at \$725,155.

Compared with the Bureau's returns for 1902, there has been an increase in the products of the fisheries of the Gulf States of 17,226,613 pounds, or 15.15 per cent., in the quantity and of \$3,016,114 or 86.31 per cent., in the value. Compared with the returns for 1908, the increase amounts to 12,649,583 pounds, or 10.69 per cent., in quantity and \$1,650,310, or 33.95 per cent., in value.

#### ROAD-BUILDING PROJECTS WITH FEDERAL AID

THE rate at which the number of Federal-aid road-building projects has increased since the war is shown in a summary relating to all such work from September 30, 1916, to April 30, 1920, which has been prepared by the Bureau of Public Roads, United States Department of Agriculture. On the latter date the states had filed with the bureau 2,885 project statements, of which 2,790 had been approved, representing 27,796 miles of highway. The totals on April 30, 1919, were little more than one third these amounts. Up to May 1 of this year 1,974 projects had proceeded to the stage at which plans, specifications, and estimates had been delivered to the Bureau of Public Roads. The plans, specifications and estimates of 1,827 of these had been recommended for approval, representing 13,845 miles.

Project agreements had actually been executed and construction work was in progress on 1,569 projects, totaling 11,987 miles. In addition, work had been begun on about 100 projects for which agreements had not actually been signed, thus expediting the progress of the work and bringing the total mileage under construction up to 13,540. The summary shows that a great reduction has been made in the time required for preliminary work before the actual construction is begun.

On the average the states have submitted

project statements for nearly 95 per cent. of their respective allotments and have entered into agreement to construct highways which call for about one half of the Federal-aid money. The projects actually completed and paid for are comparatively few, but they are materially exceeded in number by those which are practically completed. California, Delaware, Illinois, Idaho, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Minnesota, Nebraska, New Hampshire, New Jersey, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Washington, West Virginia, and Wyoming have each submitted approved project statements for all or nearly all of their allotments.

#### THE BREWSTER COLLECTION OF BIRDS

ANNOUNCEMENT is made by the American Museum of Natural History of a gift by Frederick F. Brewster, of New Haven, Connecticut, of 3,200 specimens of land-birds collected in the West Indies and South America by Rollo H. Beck, under the direction of Dr. Leonard C. Sanford. A very large part of this material, according to Dr. Frank M. Chapman, curator of the department of birds, is new to the museum's collections, and much of it is contained in no other museum in the world. The collection includes 1,500 birds from the West Indies—chiefly the high mountains of Santo Domingo, from which little-known area there is included a series of the recently discovered crossbill and Patagonia sparrow, known heretofore only from a few specimens in the National Museum in Washington; a large series of two distinct new species, known only in the Brewster collection; and the unique type of a new genus of Goat-suckers. There are also 500 birds from Bahia—of great value, since this is a type locality for many species described by the older writers; and somewhat over a thousand specimens from the extreme southern part of South America, including a representative series from Tierra del Fuego and the Falkland Islands, from which localities the Museum was wholly without material.

#### HAWAIIAN SCIENTIFIC INSTITUTIONS

THROUGH the generosity of the C. M. Cooke estate the University of Hawaai is to have a marine biological laboratory located in connection with Honolulu Aquarium at Waikiki. The last legislature placed the aquarium in the custody of the university. The laboratory is now in process of construction and will be ready for use by mid-summer. Facilities will be provided for work by visiting scientific men as well as by the students and faculty of the university. Biologists planning to visit Hawaii and wishing to use the laboratory are advised to communicate with Professor C. H. Edmondson, the director of the laboratory, as far in advance as possible. A teaching fellowship carrying a stipend of \$750 is open for the next college year and applications will be received from graduate students with sufficient training in zoology and botany.

The trustees of the Bishop Museum in Honolulu and the regents of the University of Hawaii have agreed on the fundamentals of cooperation between the two institutions in scientific investigation and the training of investigators. The general principle of reciprocity in the use of libraries, collections, apparatus and other facilities is laid down and it is also agreed that graduate students in the university may, under proper limitations, have the use of the museum and may carry on part or all of their research under the direction of members of the museum staff. Work done in this manner will be counted toward advanced degrees by the university. The plans contemplate bringing together all systematic collections not required for teaching purposes at the museum.

#### SCIENTIFIC NOTES AND NEWS

CAMBRIDGE UNIVERSITY has conferred the honorary degree of doctor of laws upon Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research.

At the centennial commencement exercises of Colby College the degree of doctor of laws was conferred on George Otis Smith, director of the Geological Survey, a graduate of the college in the class of 1893.

COLGATE UNIVERSITY at its recent commencement conferred the honorary degree of doctor of science upon Colonel Alfred Hulse Brooks, of the United States Geological Survey.

BROWN UNIVERSITY has conferred the degree of doctor of laws on Dr. Vernon Kellogg, of Stanford University and the National Research Council.

UPON the occasion of the Golden Jubilee Commencement of Syracuse University, held on June 14, the honorary degree of doctor of science was conferred upon Edward H. Kraus, professor of crystallography and mineralogy and dean of the summer session of the University of Michigan.

At the seventy-first anniversary commencement of Baylor University, the honorary degree of doctor of laws was conferred on Robert Thomas Hill in recognition of his geologic work in the southwest and the tropical and sub-tropical regions. Dr. Hill will continue his researches upon the geology and geography of the Texas and southern California regions during the summer season.

DR. ELIAS POTTER LYON, dean of the University of Minnesota Medical School, was granted the degree of doctor of laws by the St. Louis University at its recent commencement.

A TABLET in honor of Dr. Charles K. Mills was unveiled at the Philadelphia General Hospital on June 17. Dr. Mills resigned last October after forty-two years' service as chief of the neurologic staff at the hospital. The tablet is of bronze, 48 by 28 inches, with a bas-relief medallion of Dr. Mills' head surmounting it.

ELMER D. BALL, of the Iowa Agricultural College, has been appointed assistant secretary of agriculture. Since his graduation from the Iowa Agricultural College Dr. Ball has been a teacher in agricultural colleges and an investigator of scientific and agricultural problems. He has been dean of the Utah Agricultural College and director of the experiment station, and state entomologist of Wisconsin.

DR. ALBERT C. HERRE, director of the school of hygiene and professor of biology in the Washington State Normal School, Bellingham, Washington, has accepted appointment as chief of the division of fisheries in the Bureau of Science, Philippine Islands.

DR. PEYTON ROUS has been promoted to be a member in pathology and bacteriology of the Rockefeller Institute for Medical Research.

DR. MARSTON TAYLOR BOGERT, professor of chemistry in Columbia University, has been appointed by the president a member of the United States Tariff Commission.

DR. A. C. BOYLE, JR., for ten years professor of mining, metallurgy and economic geology at the Wyoming School of Mines, has been appointed geologist for the Union Pacific Railroad Company.

MR. KENNETH P. MONROE has resigned as chemist in the color laboratory, U. S. Bureau of Chemistry, Washington, D. C., to accept a research position in the Jackson Laboratory of E. I. du Pont de Nemours & Company, Wilmington, Del.

DR. A. G. HUNTSMAN, of the Biological Board of Canada, has visited Washington for a conference with the Bureau of Fisheries in regard to trade names of fishes and other aquatic products for use in the United States and Canada. Dr. Huntsman conferred also as to fishery and oceanographic investigations that may be pursued by the United States and Canada on both coasts under a cooperative arrangement.

PROFESSOR W. B. HERMS, of the University of California, has established a temporary summer laboratory in the Sacramento Valley near Vina, Tehama county, California, for the purpose of investigating certain malaria-mosquito problems in that vicinity, notably factors governing breeding habits of anophelines, their egg-laying habits and per cent. of infection. Three species of Anophelines are present; namely, *A. occidentalis* (western variety of *A. quadrimaculatus*), *A. punctipennis* and *A. pseudopunctipennis* together with a prevalence of malaria. Collaborating with Professor

Hermis is Professor S. B. Freeborn, also of the University of California and a small group of students. The present intensive investigation follows a general malaria-mosquito survey of California which was completed last summer.

PROFESSOR WARREN D. SMITH, of the University of Oregon, has been given leave of absence to spend a year in geological work for the Philippine government, as chief of the Division of Mines of the Bureau of Science at Manila.

PROFESSOR FRANK T. MCFARLAND, department of botany, University of Kentucky, has been granted a leave of absence for the year 1920-21. He will spend this summer and next year in study at the University of Wisconsin. While on leave, Professor McFarland's place will be filled by Mr. E. D. Hull, a graduate of the University of Chicago.

By action of the convention of the Sigma Xi Society at its meeting in St. Louis, a limited charter was granted to the University of North Dakota. The installation exercises of this chapter were recently held, Dean Lauder W. Jones, of the University of Minnesota, presiding. These exercises consisted in the formal installation of the chapter on the evening of June 2, followed by the initiation of four active members elected from the faculty, and five associate members from the graduates and the senior class. The exercises were followed by a banquet. On the morning of June 3, Dean Jones addressed the university convocation on the subject of "Science and industry." A fuller account of the proceedings will appear later in the *Sigma Xi Quarterly*.

DR. IRA REMSEN, formerly president of Johns Hopkins University, delivered the commencement address at West Virginia University on June 15. His subject was "This is the Age of Science." After the commencement exercises Dr. Remsen was entertained by the members of the West Virginia Alumni Association of Johns Hopkins, six of whom are heads of departments in the state university.

## UNIVERSITY AND EDUCATIONAL NEWS

CORNELL UNIVERSITY has received an anonymous gift from a professor and his wife of a trust fund for an institute of pure and applied mathematics. The gift amounts to \$50,000 and is to be held in trust for a hundred years and allowed to accumulate.

WALLACE W. ATWOOD, professor of physiography at Harvard University, has been appointed President of Clark University, succeeding President G. Stanley Hall, of the university, and President Edmund C. Sanford, of the college. Dr. Hall, who has been president of the University and professor of psychology for thirty-two years reached his seventy-fourth birthday on February 1.

HECTOR JAMES HUGHES, professor of civil engineering and director of the Harvard Engineering Camp, has been chosen dean of the Harvard Engineering School to take the place left vacant by the retirement of Dean Comfort Avery Adams.

W. H. CHANDLER, professor in pomology at the New York State College of Agriculture, has been appointed vice-director of research at the Cornell University Agricultural Experiment Station. Professor Chandler has been at the college as professor in research in pomology since 1913.

DR. NORMAN McDOWELL GRIER has been appointed professor of biology at Washington and Jefferson College to succeed Dr. Edwin Linton, who has retired under the provisions of the Carnegie Foundation.

DR. ARTHUR W. HAUPT, formerly professor of biology at Carthage College, Carthage, Ill., has been elected to the chair of biology at Saint Lawrence University, Canton, N. Y.

THE following changes have been made in the department of medical zoology of the school of hygiene and public health of the Johns Hopkins University. New appointments: Dr. Chas. E. Simon, lecturer in medical zoology; Mr. D. L. Augustine, assistant in helminthology; Dr. W. H. Taliaferro, from instructor to associate in protozoology; Dr. F. M. Root,

from teaching fellow to associate in medical entomology.

DR. LOUIS J. GILLESPIE, professor of physical chemistry at Syracuse University, who was formerly with the Department of Agriculture, Washington, D. C., has resigned to go to the Massachusetts Institute of Technology as assistant professor of physico-chemical research.

DR. ARTHUR F. BUDDINGTON, Ph.D. (Princeton, '16), and Dr. Benjamin F. Howell, Ph.D. (Princeton, '20), have been appointed assistant professors of geology at Princeton University.

## DISCUSSION AND CORRESPONDENCE

### MODERN INTERPRETATION OF DIFFERENTIALS

IN an advance copy of a note to SCIENCE, which Professor Huntington has kindly sent to me, he says that "*some indication as to the manner in which  $N$  is to vary*" is necessary to define  $dy = \lim N\Delta y$ . This is not true. Of course, there must be some relation between  $N$  and  $\Delta y$ , in order that, for example,  $\lim N\Delta y = 5$ , but the number of such relations is infinite, and it is only necessary to know that they exist. For example, if  $\Delta y = (5/N) + (8/N^2)$ , then  $N\Delta y = 5 + (8/N)$ , and for  $\lim N = \infty$ ,  $\lim \Delta y = 0$ ,  $\lim N\Delta y = 5$ . It was stated in my note which Professor Huntington is criticizing<sup>1</sup> that  $N$  varies from zero to infinity. We are not concerned with the method of approach, but only with the possible value of the limit. The preceding illustration shows that if  $y$  be an independent variable, such limit  $dy$  exists, and in any value we please to name. It is different if  $y$  be dependent, and my note in SCIENCE of May 7, contained a demonstration that  $df(x)$  exists when the graph of  $f(x)$  has a tangent, and determines its construction, corresponding to any value of  $dx$ , including in particular,  $dx = \Delta x$ , which is, of course, not always true.

The problem of differentiation is larger than that of a single value, since it determines an infinite number of corresponding values. We have the analogy of the infinite number of corresponding values of the derivative variable

and its argument  $x$ . We justify this variable as a limit on the ground that it is a true limit for each numerical value of  $x$ . The example having been set, its extension to differentials can not be denied.

The infinite number of corresponding differentials ( $dx, dy, dz$ ) pertain to the one set of corresponding variables ( $x, y, z$ ), just as the increments ( $\Delta x, \Delta y, \Delta z$ ) pertain to it, and are *corresponding increments of the instantaneous state of the variables*, also, *increments in the first ratio* (Newton's "prime" ratio), etc. This is not a vague idea but one which, in numerical cases, determines numerical values. The source of this terminology is the physical idea that *equimultiples of very small simultaneous increments are approximately increments of the instantaneous state*. The differential analysis of Newton, which carries this idea to its logical conclusion, is therefore the mathematical foundation for such physical idea.

It is easy to make statements appear vague by separating them from the facts on which they are based, and such facts appear in the article from which Professor Huntington quotes, with a figure showing the *finite equimultiples* which are becoming exact differentials—differentials which his "modern" method can not represent, since they pertain to a system of two independent variables, and of which the derivative calculus can give no adequate idea, although they are of great practical importance.

Such so-called modern method is crude in its limitation  $dx = \Delta x$ , narrow in its application *only to plane curves in rectangular coordinates*. A natural extension to space is impossible, but Newtonian differentials are coordinates of tangent planes, from their points of contact as origin. By Newton's method, all kinds of continuously variable quantity, in plane or space, lines, areas, volumes, forces, may have corresponding differentials represented in finite quantities of the same kind, and by the limits of finite and visible values.

ARTHUR S. HATHAWAY

ROSE POLYTECHNIC INSTITUTE

<sup>1</sup> SCIENCE, February 13.

## NOTE ON DISTRIBUTION AND SPERMATOGENESIS OF MYRIAPODA

DURING the spring of 1912, while working on the Myriapoda of Kansas at the University of Kansas, the writer had occasion to examine a bottle containing several specimens of *Scolopendra*, each of which had been dissected and had had the gonads removed. As there was no label with them, the matter was called to the attention of Dr. C. E. McClung, who stated they were some of the specimens used by Dr. Maudslayi W. Blackman in his work on the spermatogenesis of the Myriapoda, which he started at the above-named institution and later continued at Harvard University. As a result of his observations, the writer is convinced a mistake was made by Blackman in the identification of the form used.

Blackman's first paper<sup>1</sup> on the subject states that the specimens used were collected in June, 1900, in Russell county, Kansas, by Mr. W. S. Sutton and are "the large reddish-brown *Scolopendra*, found abundantly in the southwest. It is a large centipede, about four inches long and four lines across." In his second paper,<sup>2</sup> he identifies the specimens he was working on as *S. heros*, but in regard to the location where his material was collected, simply states that this paper is in the nature of a by-product of "a detailed study of the spermatocyte changes in *Scolopendra heros*, now practically ready for publication." This second paper was published from the University of Kansas, so evidently he used the same material that he did in his first and third papers on the subject. In his third paper<sup>3</sup> of the series, he identifies his speci-

mens as *S. heros*, and says that most of the work was done on forms collected in Russell county, Kansas, but "later a number of specimens of the same variety of *S. heros* were received from Beulah, Colorado, through Mr. R. E. Scammon." The last paper<sup>4</sup> in the series referring to this particular species of centipede was based on the same material "which served as a basis of several previous papers (Blackman :01, :03, :05), the majority of the slides having been mounted nine years."

The specimens seen by the present writer, and which formed part of Blackman's material, were *Scolopendra polymorpha* and not *S. heros*, as he designated them. A mistake in the identification of these two forms could easily occur, as each species is very variable not only in color but also in anatomical details, and they have been considered as synonymous by some writers, for example Bollman,<sup>5</sup> whose writings were undoubtedly followed in making the original identification. However, they have been considered as distinct species for some time,<sup>6</sup> the main difference between the two being that *S. heros* has two fine longitudinal lines or furrows on the cephalic plate which diverge cephalad, while *S. polymorpha* is without these lines.

The geographical distribution of the two forms also confirms the fact that Blackman was mistaken, as there is no record of *S. heros* having ever been taken north of the southern tier of counties in Kansas, while *S. polymorpha* is known to occur throughout the state.<sup>7</sup> Russell county, where Blackman's

<sup>1</sup> Blackman, M. W., "Spermatogenesis of the Myriapods. I. Notes on the Spermatocytes and Spermatids of *Scolopendra*," *Kans. Univ. Quart.*, 10: 61-76, pls. 5-7, 1901.

<sup>2</sup> Blackman, W. M., "Spermatogenesis of the Myriapods. II. On the Chromatin in the Spermatocytes of *Scolopendra heros*," *Biol. Bull.*, 5: 187-217, 22 figs., 1903.

<sup>3</sup> Blackman, W. M., "Spermatogenesis of the Myriapods. III. The Spermatogenesis of *Scolopendra heros*," *Bull. Mus. Comp. Zool. Harvard*, 48: 1-138, pls. 1-9, 1905.

<sup>4</sup> Blackman, M. W., "Spermatogenesis of the Myriapods. VI. An Analysis of the Chromosome Group of *Scolopendra heros*," *Biol. Bull.*, 19: 138-159, pls. 1-2, 1910.

<sup>5</sup> Bollman, Charles Harvey, "The Myriapoda of North America," *Bull. U. S. Natl. Mus.*, No. 46, 1893. (See pg. 175.)

<sup>6</sup> Kraepelin, Karl, "Revision der Scolopendriden," *Jahrb. Hamb. Wiss. Anat.*, 20: 1-276, 1903.

<sup>7</sup> Gunthorp, Horace, "Annotated List of the Diplopoda and Chilopoda, with a Key to the Myriapoda of Kansas," *Kans. Univ. Sci. Bull.*, 7: 161-182, pl. 20, 1913.

specimens came from, is some one hundred and twenty-five miles from the southern boundary, in the center of the state. Regarding the specimens from Beulah, Colorado, which Blackman recognized as "the same variety of *S. heros*" as those collected in Kansas, the altitude of this place (over 5,000 feet) would strongly preclude the possibility of *S. heros*, a sub-tropical form, being found there. Also, the fact that Blackman does not record any difference in the germ cells of these Colorado specimens from those collected in Kansas would prove that they were one and the same species.

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#### QUOTATIONS

##### THE ENDOWMENT OF BIOCHEMICAL RESEARCH IN ENGLAND

OUR university correspondent at Cambridge sends us the announcement of a munificent benefaction about to be made for research in biochemistry. A minimum aggregate expenditure of £165,000 is contemplated, and this sum, if necessary, will be supplemented. The scheme includes the erection of buildings on a site to be provided by the university, equipment, provision for maintenance, £25,000 for the endowment of a professorship, and £10,000 for a readership. The money comes from the residuary estate of the late Sir William Dunn, banker and merchant, and Liberal member for Paisley. The testator died in 1912, leaving a fortune valued at a million pounds, and appointing the directors of the Commercial Union Assurance Company as trustees, with some discretionary powers as to the disposal of his residual estate. There were pencil alterations in the text of the will, and it was only after a lawsuit that the trustees were able to act. They appointed an advisory committee under the chairmanship of Sir Jeremiah Colman, and many schemes were considered. Numerous and substantial gifts have been made to well-known philanthropic institutions, but the trustees reserved a large sum to provide a lasting and fitting memorial of Sir

William Dunn's generosity and to carry out his expressed wishes for the alleviation of human suffering and the encouragement of education. The benefaction to Cambridge should serve both these objects. Certainly it represents one of the most munificent and complete gifts ever made to one of the older universities. Only last month we congratulated the University of Oxford on Mr. Edward Whitley's offer of £10,000 towards the endowment of a chair of biochemistry, and on a donation of £5,000 from the British Dyestuffs Corporation to the laboratory of organic chemistry. We may hope that the friends of Oxford and of scientific research will do something to equalize the good fortune that has come to Cambridge. The chemical activities of the living cell and the living tissues provide a limitless field of research. Knowledge of them is only beginning, and until the methods and results of biochemistry have been developed, the practise of medicine will remain empirical, and fashions in drugs will change as quickly as fashions in ladies' hats. The old universities have the tradition of research, and their spirit of detachment supplies an atmosphere suitable to inquiries not too closely bound to immediately utilitarian objects. We rejoice in the great opportunity given to Cambridge, and do not doubt but that she will prove worthy of it—*The London Times*.

#### SCIENTIFIC BOOKS

*Die Stämme der Wirbelthiere.* By OTHENIO ABEL. Publ. 1919 by Verein wiss. Verlegn., W. de Gruyter and Co., Berlin and Leipzig. 914 pages, 669 text figures.

It is to be regretted that there is no good comprehensive modern text-book in English dealing with vertebrate paleontology. The researches of the last twenty years have perhaps made less change in fundamental viewpoints and theories in this than in some other branches of science. But they have added enormously to the data of facts upon which it rests, and knit closer its relationships with the cognate sciences, geology on one side, zoology and comparative anatomy on the other.

Dr. Abel is professor of paleobiology at the University of Vienna, a pupil of the great Belgian scientist Louis Dollo, and a leading authority in his profession. He is the author of two earlier text-books, "Paleobiologie" and "Die vorzeitlichen Säugethiere," the first of which was reviewed in *SCIENCE* some years ago.

The present volume treats of the origin and evolution of the various phyla ("Stämme") of vertebrates as shown in the paleontologic record. It is concerned almost wholly with extinct forms; and thanks to this limitation the author has been able to give an unusually full treatment and discussion, especially of the reptiles and Amphibia. The illustrations, while somewhat crude artistically, are excellent for teaching purposes, and its full discussion and fair treatment of recent foreign discoveries are remarkable in a volume prepared and published under war conditions. From first to last Dr. Abel has endeavored to discuss the evidence and give reasons for the conclusions adopted, leaving the way open for difference of opinion on many doubtful problems. A certain unevenness of treatment is manifest, both in the discussion and the taxonomic arrangement, and many details of presentation and classification are open to criticism, as is inevitable in a volume of such wide scope and fundamental treatment. From errors of fact the book is singularly free.

A classified list of the orders and families accepted, with characteristic genera, serves as a preliminary conspectus. To the fishes are allotted 160 pages, partly introductory and dealing chiefly with the early and primitive types. The vast variety of modern bony fishes are treated in a very cursory manner. The Amphibia cover 110 pages, devoted mostly to the Paleozoic types and their relations to the higher vertebrates. The extinct reptiles are quite fully treated, the discussion covering some 355 pages. The most serious criticisms to be made in this section are of the splitting of the pterodactyls into two distinct orders, and the attempt to limit the term dinosaurs to one of the two great orders of gigantic land reptiles that are now under-

stood to be included in the old usage of the name. It would be better to retain it with the old scope but in a general unsystematic sense, like "pachyderms" among the mammals. On the other hand, the discussion of important researches and discoveries among fossil reptiles and their bearing on the evolution of the vertebrates affords an excellent synthesis of recent progress in the science. Birds are a rather minor group among fossil vertebrates, and 23 pages suffice to cover all the important types in their evolution.

The treatment of the Mammalia is relatively brief, covering 167 pages, passing very briefly and uncritically over some of the orders, and hardly touching upon the Primates, but more extended with other groups, and especially authoritative in the Cetacea, upon which the author has published several very valuable researches.

While by no means endorsing all of the author's views upon problems of evolution and classification, the present reviewer does not hesitate to commend Dr. Abel's work as highly authoritative and up to date, admirably presented as to form and reliable as to fact. The treatment of the subject differs widely from that in the new edition of Zittel's "Grundzüge der Paläontologie," recently revised by Schlosser and Broili, which affords in many ways an excellent supplement for Abel's volume, especially in its more comprehensive treatment of the Mammalia.

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#### SPECIAL ARTICLES

##### AN ULTRAMICROSCOPIC STUDY OF THE TWO STAGES OF BLOOD COAGULATION<sup>1</sup>

SCHMIDT<sup>2</sup> has described carefully the process of coagulation as it may be followed with the naked eye in the cell-free plasma of a slowly-clotting mammalian blood (horse). He drew attention to the fact that the process may be

<sup>1</sup> From the Physiological Laboratory of the Johns Hopkins University.

<sup>2</sup> Schmidt, "Zur Blutlehre," Leipzig, 1893, p. 262.

separated into two distinct stages from the standpoint of the changing physical properties and macroscopical appearance of the plasma during the progression of clot-formation. First, the fluid plasma is seen to be transformed into a definite but transparent coagulum of which, "on pressure between the fingers, almost nothing remains." This delicate coagulum marks the first visible or palpable stage in the development of the clot. On standing, the transparent, almost structureless, yellow coagulum is observed to become gradually more and more turbid; until at length the second stage is reached, in which the coagulum appears quite opaque and whitish, and assumes the typical characteristics of a firm, fibrin clot. By the use of paraffined vessels and low temperature, the coagulation of human or cat's blood may be delayed sufficiently to permit centrifugalization in order to obtain a clear, cell-free plasma for observation; or one may study the coagulation which follows the recalcification of a centrifugalized oxalated plasma. In either of such quickly-clotting plasmas it is, of course, more difficult, but nevertheless quite possible, to divide the progress of coagulation into the two stages described above.

The transparent-stage and the opaque-stage of blood-coagulation are certainly striking physical phenomena. The question accordingly presents itself: Has each of these stages a separate, underlying causal reaction, or do they represent gradations in a continuous transformation of a sol into a gel? Are the two separate stages superimposable upon separate reactions occurring between the coagulation factors, or does the transparency or opacity of the plasma, as well as its consistency, merely reflect the extent of fibrin-formation?

It seemed that this question might find immediate solution if it could be determined at what point fibrin first makes its appearance during the coagulation of a tube of plasma. In comparison with the appearance of the fibrin which we recognize in a firm, opaque clot, certainly the transparent-stage appears to be entirely fibrin-free. Now it is well known that during coagulation, the formation of

fibrin needles can be followed from the beginning with the aid of the ultramicroscope. Howell<sup>3</sup> has described and figured this beautiful phenomena, in which "bright specks appear first as short rods, which exhibit a genuine saltatory movement, jumping abruptly into and out of focus, and quickly fusing to form longer rods and needles" of fibrin. It was at the suggestion of Dr. Howell that it was decided to use the ultramicroscope as a method of approach to the solution of the question outlined above. The Siedentopf and Zsigmondy slit ultramicroscope, with water-immersion objective was the instrument used; illumination was obtained from a carbon arc-light.

After trying various methods, the following procedure was found to yield the most satisfactory results: a horse was bled from the external jugular vein through a paraffined needle into a paraffined tube packed in ice. The blood was taken to the laboratory, filtered through a paraffined funnel surrounded by an ice-jacket, and the cell-free plasma caught in a second iced, paraffined tube. Plasma was then, by means of a chilled paraffined pipette, introduced in rapid succession into (1) the cell of the ultramicroscope; (2) a control cell of the same size and shape, not attached to the ultramicroscope, and (3) a homeopathic vial (into which  $\frac{1}{2}$  c.c. of plasma was placed in each experiment). These three containers could be filled within ten seconds, so that coagulation began in all three practically at the same moment. To eliminate any error of interpretation which might conceivably arise from the fact that one vessel was filled a few seconds before another, the order in which they were filled was varied in different experiments. There was, however, no evidence indicating that this theoretical source of error had the slightest influence upon the results in any experiment.

The rationale of using three plasma containers in these experiments may be here explained: (1) The cell of the ultramicroscope was observed closely after filling, in order to determine the time of appearance of the earliest visible needles of fibrin; (2) the homeopathic

<sup>3</sup> Howell, *Am. Jour. Phys.*, 1914, XXXV., 143.

vial served to hold a gross specimen of coagulating plasma in which the time of appearance of the transparent and opaque stages could be compared with that of the appearance of fibrin needles in the ultramicroscope cell. However, as it was found difficult to determine the earliest moment at which the viscous plasma could be considered to have entered the gel-stage, a more delicate criterion of the onset of this transparent stage was devised by using (3) the control cell. This cell, being of the same size and shape as the ultramicroscope cell and being filled at the same time, could be assumed to favor a progress of coagulation synchronous with that occurring within the cell of the ultramicroscope. The tubal prolongation of the control cell was immersed at frequent intervals beneath the surface of a normal saline solution, and a very small amount of plasma allowed to escape into this fluid. If the plasma at once diffused through the salt solution it is clear that it was still in a state of fluidity; if, however, it emerged from the tube in the form of a delicate, transparent "worm" which floated in the solution, preserving the contour of the tube, the plasma was considered to have entered the transparent gel-stage. This proved to be a very delicate test; transparent "worms" could be obtained at such an early stage that agitation of the liquid in which they were suspended would cause them to vanish into the solution—a degree of gel-formation too slight to be discerned by the observation of plasma contained within the homeopathic vial.

In each experiment, the time at which the containers were filled was recorded; likewise a note was made of the time at which fibrin-needles were first to be seen with the ultramicroscope, at which a transparent worm-like gel could first be obtained from the control cell, and at which an opaque clot appeared in the homeopathic vial. The point of interest lies, of course, in the time relation between the occurrence of the transparent gel-stage (as evidenced by the control tube) and the first appearance of fibrin needles under the ultramicroscope. A typical experiment will serve to exhibit this relation:

BLOOD OBTAINED FROM VEIN (HORSE) AT 2:25 P.M.;  
FILTERED AT 3:30 P.M.

Time	Ultramicroscope Cell	Control Cell	Homeopathic Vial
3:37...	Plasma introduced	Plasma introduced	½ c.c. plasma introduced
3:39...	No fibrin needles	Plasma liquid	Plasma liquid
3:41:30	Scanty fibrin needles	Plasma forms "worm"	No definite change
3:44...	Fibrin needles more numerous	Plasma forms firmer "worm"	Transparent gel present
3:50...	Fibrin needles very dense	.....	Opaque clot
4:04...	Refilled with plasma	Refilled with plasma	½ c.c. plasma introduced
4:06...	No fibrin needles	Plasma liquid	Plasma liquid
4:08...	No fibrin needles	Plasma liquid	Plasma liquid
4:09...	No fibrin needles	Plasma liquid	Plasma liquid
4:11...	Fibrin needles present	Plasma forms "worm"	Plasma liquid
4:12:30	Fibrin needles more dense	.....	Transparent gel present
4:16:30	Fibrin needles very dense	.....	Opaque clot

Such experiments demonstrate clearly that all of the reactions leading to the formation of fibrin have occurred before the transparent gel-stage appears; for fibrin needles are demonstrable in the coagulating plasma in the earliest stages of gel-formation. Indeed, in a number of experiments, a few scattered needles of fibrin were seen with the ultramicroscope before any gel-formation could be demonstrated in the plasma. Microscopically then, the only difference between the so-called transparent-stage and opaque stage of coagulation lies in the greater number of fibrin needles present in the latter. Their gradual development can be watched with the ultramicroscope, and many such experiments (in which the oxalated and unoxalated plasmas of man, horse, cat and dog, were tested) prove clearly that the macroscopically observed transition of a liquid plasma through a transparent gel-stage into an opaque fibrin clot, represents merely a continuous progression of fibrin-formation.

#### SUMMARY

There is no reaction-basis for the division of the process of blood-coagulation into the

two stages (transparent and opaque) which appear so strikingly in slowly-clotting mammalian blood. These stages are superficial phenomena which merely reflect the extent of fibrin-formation. Coagulation is a gradual continuous process of fibrin-formation; and in the clotting of normal plasma, fibrin needles can be demonstrated in the earliest appreciable coagulum, however delicate, transparent or gel-like.

ARNOLD RICE RICH

### THE KENTUCKY ACADEMY OF SCIENCE

THE seventh annual meeting of the Kentucky Academy of Science was held at the University of Kentucky, Lexington, on Saturday, May 8, President P. P. Boyd presiding. The secretary's report showed a membership of 110, and 24 new members were elected at this meeting. Resolutions were adopted accepting the terms of affiliation with the American Association for the Advancement of Science and establishing two classes of active members: national and local; and looking to cooperation with the American Ecological Society in preservation of natural conditions. The principal address, "The twentieth century's contribution to our knowledge of the atom" was delivered in the afternoon by Professor R. A. Millikan, who was afterwards elected an honorary member of the academy.

The following program of papers was rendered:

President's address. *The future of the Kentucky Academy*: DEAN PAUL P. BOYD, University of Kentucky. The speaker presented first the summaries of state academies given by Mr. D. D. Whitney in SCIENCE of December 5, 1919 and then told the results of a questionnaire which he had lately sent to secretaries of state academies, the object being to ascertain the future and the field of such organizations. He concluded that there is a definite need for them and urged that the Kentucky Academy begin a forward movement in order to fill more properly its field in the nation-wide organization of science. Some of his suggestions were that the academy cooperate more effectively with the national bodies; that membership be extended more widely to educational and industrial plants; that science clubs be organized throughout the state; that better science teaching in the high schools be promoted; that funds be solicited from the legislature and private sources for publication and research funds; that committees be formed

for the study of important state problems and for state surveys; and that recommendations be formulated for presentation to the next legislature.

*Blood lines of genetic value*: W. S. ANDERSON, Kentucky Experiment Station. In the domestic breeds of live stock great sires seldom produce more than one or two sons that are greater progenitors than themselves. This means, in blooded stock, that the greatness of any given blood line is handed on by one or two in any one generation, the others of the generation merely add members. In support of the statement, the great sires of nine breeds of domestic animals were cited and the few sons of each were named who have been instrumental in handing on the breeds.

*Failure of lettuce to head*: A. J. OLNEY, and W. D. VALLEAU, Kentucky Experiment Station. The various physiological troubles associated with the failure of greenhouse head lettuce, including those known as rosette, tip-burn, black heart and elongation of the central stalk with the production of laterals (Rio Grande disease), have been found to be associated with a root rot apparently due to *Fusarium*, sp. Soil sterilization by steam and formaldehyde have only partially controlled the trouble, due probably to incomplete sterilization of the lower soil layers.

*Variation in *Abutilon Theophrasti* Medici*: CHARLES A. SHULL, University of Kentucky. This paper is a report of progress in an investigation of variability in the number of carpels in the ovaries of *A. Theophrasti*. The range of variability is from ten to seventeen, with the mode usually on fourteen or fifteen. The material shows a skewed frequency distribution, and tendency toward half Galton-curves. A number of plants have been found with half curves and the mode on 15. But whenever a number of plants are counted together, there are usually a small number falling on sixteen. Only three specimens in about 8,000 had seventeen carpels to the ovary. The mode falls on a lower number in material collected in Kansas than in similar material from Kentucky. The drier climate of Kansas is probably responsible for this difference. If plants from an unfavorable habitat are counted the mode is found to be depressed. The modifications of the variability curves noted are probably related rather directly to nutritional conditions. Heredity and suboptimal nutrition are believed to be responsible for the half-curve variability.

*Some factors to be considered in attempting to communicate with supposed inhabitants of Mars*:

HENRY MEIER, Centre College. In the first place, the probable low temperature, rarified atmosphere and absence of water are against the existence on the planet of beings endowed similarly to us. Ability to signal by light is negatived by the fact that the earth's atmosphere would absorb about 40 per cent. of the light sent out, and by the great distance. The author estimates that an area of light 10 miles square, on the earth, if seen from Mars through a telescope magnifying 500 times, would appear like an area 1 inch square, viewed at a distance of 500 feet. The possibility of signaling by radio is negatived by the distance, it being computed that it would require a current of a million amperes at the sending station in order to obtain one of one ampere at a receiving station on Mars, when the planet is nearest the earth. Besides, the powerful currents radiated from the sun would probably overwhelm the weak waves from the earth.

*The future of nutrition and medicine:* DR. A. W. HOMBERGER, University of Louisville. The paper brought out the close relation between diets in health and disease. It laid emphasis upon the benefits derived from urine and blood analyses. Urine analysis is not new and yet, with the modern methods of blood analysis, it becomes a new and valuable aid in treating diseases. The direct relations were illustrated by the conditions found in the body under diabetic conditions. Tables showing analyses representing the work of some 80 men on blood and urine were presented—also a classified schedule of dietaries the object of each group being to throw together foods particularly adapted to the diseases involved. The author predicts that in the future there will be a closer scientific relation between the nutrition of the sick and medicine than there has been in the past.

*Asphalt coal:* W. R. JILLSON, state geologist. By title.

*Note on the occurrence of cretaceous sediment in the "between the rivers" section in Trigg and Lyon counties:* W. R. JILLSON, state geologist. By title.

*Some observations on the life-history of the praying mantis:* MISS MARY DIDLAKE, Kentucky Experiment Station. Two species, the common *Stagmomantis carolina* and a big Chinese one, *Tenodera sinensis*, were carried through several generations in as many successive years, reared in the laboratory, individuals being kept separate, at first in homeopathic vials, then in 4-ounce, wide-mouthed bottles and finally in 6-inch stender dishes.

Hatching, molting, regeneration of limbs and antennae, mating, egg-laying, all were frequently observed and recorded. It was found possible to distinguish the sexes after the first molt and with certainty after the second. The native species required about 80 days to become adult, males commonly molting only 6 times and females usually 7 times. The Chinese species averaged 78 days to adult emergence and both sexes molted 7 times, a few individuals requiring 8 molts.

*Materia prima:* REV. E. L. VAN BECELAERE, Cardome. The medieval conception of the "Materia Prima" may appear thoroughly superseded by the discoveries of modern chemistry; however, such a conception, if properly understood, finds a confirmation in them rather than a disproof. The possession of a similar order of fundamental properties by each one of the elements recognized by modern chemistry, in spite of the differentiations peculiar to each of them, reveals one substratum common to all, although diversified in each one. That substratum is the "Materia Prima" accessible only to the mind, yet real and existing in each of the elements.

*Some interesting fungi of the Kentucky Mountains. The lichens of Cowbell Hollow:* G. D. SMITH, Eastern Kentucky State Normal School. Nearly 100 excellent lantern slides in natural colors, prepared by the author, were exhibited and explained, illustrating fungi and lichens observed.

*The value of memory systems:* J. J. TIGERT, University of Kentucky. An experiment is described with a class of 45 students in psychology. The test consisted in having the class memorize an extract from Keats, before studying the memory system, reproducing the words and ideas after three minutes and repeating the same process with a similar extract after studying the system. The result was negative.

*A little-known subterranean crayfish:* H. GARMAN, Kentucky Experiment Station. The underground streams of Kentucky are inhabited by an interesting crayfish with small eyes that lives and breeds at all times in these subterranean waters, only appearing in any numbers at the surface during freshets and retreating again from the light when it has an opportunity. It appears to be the eyed crayfish of early explorers of Kentucky caves, who assumed that it was merely a stray from among ordinary eyed crayfish of surface waters and regarded as identical with the widely distributed *Cambarus bartoni*. Somewhat recently it has been described as a variety of this surface-water

species by W. P. Hay, who named it *C. bartoni*, var. *tenebrosus*. It is a good species, however, of different general conformation from the species named, with which it does not intergrade. In fact, the surface-water species does not occur in some localities in which this small-eyed species is found. As a valid species it is believed to be entitled to the name *Cambarus tenebrosus*.

*A new phyllopod crustacean from Kentucky*: H. GARMAN, Kentucky Experiment Station. Temporary pools in Bluegrass Kentucky sometimes yield in early spring a species of *Eubrachipus* differing from the common species (*E. vernalis*) of eastern states and also from those found in Illinois and other middle states. The name *Eubrachipus neglectus* is assigned to it. During the thirty years it has been known to the author it has diminished in numbers, owing to changing conditions, and seems likely to become extinct; it has, in fact, disappeared in certain pools where thousands could have been secured twenty-five years ago.

*Studies in the etiology of infectious abortion in live stock*: E. S. GOOD, Kentucky Experiment Station. *Bacillus abortus* Bang is the organism causing the disease in the cow, in the United States, the same as in foreign countries. In 1911, a bacillus was isolated at the Kentucky Station from an aborted foal which we placed in Sub-group 2 of the Colon-typhoid group, which was found to be the cause of the disease in mares and jennets in Kentucky. Since that time, this germ has been found to be the causative agent of the disease in different states of this country, also in Canada, Holland and Sweden. Our results in immunizing mares against the disease are encouraging. Our investigations, so far, show that the *Bacillus abortus* Bang is the causative agent of the disease in sows.

*Mineral constituents of the paired seeds of cocklebur*: J. S. MCHARGUE, Kentucky Experiment Station. The impression is general that one of the two seeds of a cocklebur (*Xanthium*) will germinate the first spring after maturity and the second will remain dormant until the second spring thereafter. Previous investigators have attributed this apparent dormancy to inherent differences in the embryos and the seed coats. The writer finds that both seeds, if well developed, will germinate at approximately the same time, if they are removed from the burs and planted in moist sand. If allowed to remain in the burs, only one seed germinates until the bur disintegrates and decays, when the second seed will germinate. The mineral

constituents contained in the two seeds were found to be practically the same. The large seeds average about 65. mgs. and the small seeds about 45. mgs. The large seeds produce larger seedlings. This is accounted for by the fact that a large seed contains much more plant food than a small one.

*Hydrogen ion concentration and biological reactions*: D. J. HEALY, Kentucky Experiment Station. The fundamental importance of hydrogen ion concentration in the study of colloids, gels, enzymes and microbes was pointed out and illustrated by exhibits. An organic colloidal liquid at pH7.8 could not be past through a Pasteur-Chamberland F. bougie, but on adjusting the value to pH2, it passed easily. A 10 per cent. bacto-gelatin at pH5 formed a perfect gel, but with acidity equal to N/2 HCl or alkalinity of pH10, there was no gel. The oxidase of raw potato or apple was quite active at pH1.7, as shown by change in color of slices exposed to the air, but when fresh slices were soaked 15 minutes in water adjusted to pH1 and pH1.4, respectively, they dried in the air, without material change of color. A bacillus isolated from the afterbirth from a mare grew readily on agar slants of pH6.8 but failed to grow on similar slants at pH6.4.

*A study of inheritance of coat colors in Jersey cattle*: J. J. HOOPER, University of Kentucky. Studies of inheritance of Jersey cattle coat colors by the author show that white spots are recessive to dominant solid color, and a white tongue and tail-switch also are recessive. Colors of 1,145 calves were tabulated and compared with those of their 2,290 sires and dams. Some bulls studied seemed to be pure dominants, as their calves were all solid in color, although as many as a hundred were sired by each bull. It was found that 66 per cent. of Jersey cattle are solid in color and have black tongue and switch, while 12 per cent. are broken and have white tongue and switch; 3.6 per cent. are solid and have white tongue and black switch, etc.

*Animal versus vegetable proteins in the ration of laying hens*: J. HOLMES MARTIN, Kentucky Experiment Station. An experiment, now in its third year is described, in which 4 pens of 25 S. C. White Leghorn pullets, each, are being fed a basic ration of shipstuff and ground oats, supplemented by animal and vegetable protein carriers. The total egg production per pullet for the pen receiving butter-milk was 338 eggs; for that receiving tankage, 268; for that receiving tankage and cotton-seed

meal, 208; and for that receiving cotton-seed meal, 55. On reversing the rations in the cottonseed-tankage and cotton-seed pens, the egg production was reversed, showing that the difference in production depended on the ration. All pens received oyster shell, grit and charcoal.

*The seed corn situation in Kentucky:* W. D. VALLEAU, Kentucky Experiment Station. Investigations carried on at the Kentucky Experiment Station indicate that practically all seed corn in the corn belt is infected with *Fusarium moniliforme* Sheldon, and that this organism is capable of causing a root and stalk rot of corn. Infection on an ear appears not to be localized. Slightly infected seed may show no signs of infection, if grown only for a period of seven or eight days. Reddish discolorations developing in the seed coats during germination are an indication of infection. Seed studied was obtained from Kentucky, Georgia, Mississippi, Tennessee, Kansas, Arkansas, Missouri and Minnesota.

*Veterinary science:* W. W. DIMOCK, Kentucky Experiment Station. The author stressed the pressing necessity for research upon the nature and causes of diseases in live stock. He showed that the future of animal industry depended upon the control of animal diseases and that control can be secured only after the cause is known. He cited as an example the need for exact knowledge of the life histories of the internal parasites known as nematodes and showed how extensive are their ravages in horses. He believes that here, in their life history and in their effect on the host, is a field holding great promise to the investigator.

*Notes on the rapid analysis of magnesian limestone:* S. D. AVERITT, Kentucky Experiment Station. A differential method for the analysis of relatively pure magnesian limestone, without an actual determination of either Ca or Mg, which is quite rapid and sufficiently accurate for agricultural and most other purposes, is described. Determinations to be made are, A, neutralizing power of the limestone against  $N/2HCl$ , expressed as  $CaCO_3$ ; B, weight of insoluble matter +  $NH_4OH$  precipitate, from the same portion. Then

$$100 - B = \% CaCO_3 + MgCO_3,$$

and

$$5.35 (A - (100 - B)) = \% MgCO_3.$$

*Notes on light and light pressure:* C. C. KIPPLINGER, Mt. Union College, Alliance, Ohio. Some evidence is presented indicating that mass is not a universal property of light and certain photo-

chemical absorption experiments are described which show no measurable increase in weight of the reagents, following the action of light.

*Experiments with lime, acid phosphate and soil fungicides on land infested with root-rot disease of tobacco:* G. C. ROUTT, Central Experimental Farm, Ottawa, Canada. Experiments are described looking to the possible control of the root-rot disease by applications of lime, acid phosphate, mixtures of lime and sulfur, dilute sulfuric acid, land plaster, copper sulfate, potassium polysulfid, gas lime, ferrous sulfate and formaldehyde. Acid phosphate seemed to be very beneficial in some instances, as did sulfuric acid, but the majority of the experiments gave negative results. The author concludes that the disease can not be controlled in this way.

*Plant growth:* G. D. BUCKNER, Kentucky Experiment Station. Comparative study was made of the translocation of the ash, phosphorus, calcium and magnesium from the cotyledons of germinating garden beans, *Phaseolus vulgaris*, when grown in distilled water culture and in garden soil. In the distilled water culture 55 per cent. of the original ash, 57 per cent. of the phosphorus, 25 per cent. of the calcium and 59 per cent. of the magnesium was translocated to the seedling, while, in the seedlings grown in garden soil, 91 per cent. of the ash, 92 per cent. of the phosphorus, 78 per cent. of the calcium and 83 per cent. of the magnesium was utilized by the seedling. The abnormal condition caused by the distilled water culture is shown and that less calcium than any of the other elements studied was removed from the cotyledons by the growing seedling is suggestive of its insoluble form in the cotyledons and its structural function.

ALFRED M. PETER,  
Secretary

## SCIENCE

A Weekly Journal devoted to the Advancement of Science, publishing the official notices and proceedings of the American Association for the Advancement of Science

Published every Friday by

THE SCIENCE PRESS

LANCASTER, PA.

GARRISON, N. Y.

NEW YORK, N. Y.

Entered in the post-office at Lancaster, Pa., as second class matter